APPARATUS

SILVER-SILVER CHLORIDE SPONGE ELECTRODES FOR SKIN POTENTIAL RECORDING

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During research over the last two years involving psychophysiological measurements, it has been desirable to make measurements of absolute level of skin-potential as well as changes in level in response to stimulus-conditions. It was found that the accuracy of potential recording was hampered by the inadequacy of the types of electrodes than currently in use. Such electrodes showed drifts and large biases.

In an attempt to overcome these difficulties, the properties of the non-polarizable silver-silver halide electrode widely used as a reference electrode in electrochemical measurements were investigated. This type of electrode seemed to have the basic characteristics required. A modification of this type of electrode had already been used by Köhler *et al.*[1] for recording cortical potentials.

An electrode rugged enough for both research and routine clinical use that could be prepared by a relatively simple, standard, and economical procedure was desired. Thus, we wished to avoid a liquid contact medium and a mercury terminal, which they used. The following is a description of a silver-silver chloride electrode that has given very satisfactory results in over two years of polygraphic recording.

The electrode has three parts (see Fig. 1): (1) an outer casing of durable plastic; (2) the inner core of silver-silver chloride; and (3) the metal terminal assembly to which the recording leads may be attached. The component parts will be described in order.

(1) Casing. The casing is machined from 0.75 in. clear-cast lucite rod. The lower half of the casing is 1 cm. high and contains a central chamber 7 mm. in diameter and 8 mm. deep, which holds the contact medium. The upper half of the casing is

* This research was supported in part by a Public Health Service Research Grant No. N2820 (A) from the Institute of Mental Health, Public Health Service, and in part by a grant from the Society for the Investigation of Human Ecology.

[1] Wolfgang Köhler, Richard Held, and D. N. O'Connell, An investigation of cortical current, *Proc. Am. philos. Soc.*, 96, 1952, 290-330.

turned down to equal in diameter the head of the terminal stud (6.6 mm.). This provides a column of convenient diameter for use with standard *EKG* straps. The center column is drilled and threaded to a depth of 8 mm. to fit the terminal stud, and a center hole through which the platinum wire of the core may be led is drilled with a No. 60 drill.

(2) Inner core. The silver-silver chloride core is prepared by a modification of methods described by Janz and Taniguchi.[2] They are of the thermal-electrolytic type. Lengths of platinum wire, B. & S. Gage No. 25, are cut 3 cm. long, cleaned in HCl, dried, and sealed into previously cleaned 6 cm. lengths of soft glass tubing that 2 cm. extends outside the tubing and the portion inside the tubing can make contact with mercury poured into the tubing. The end of the wire outside is looped at its end and again cleaned. This is then dipped in a paste of purified silver oxide along the entire length of the protruding wire and reduced in an electric oven at 400°C. Care must be taken to coat the entire length of the wire. This procedure of

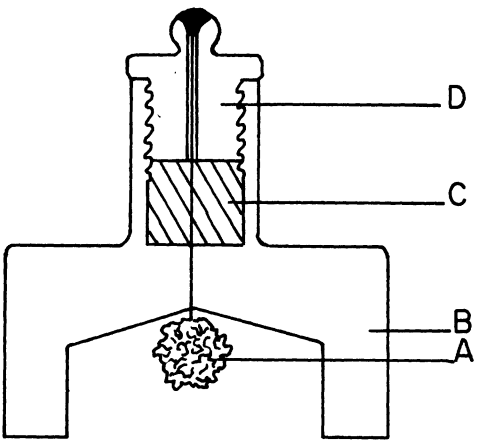

FIG. 1. CROSS-SECTION OF THE ELECTRODE

A = inner core of chloridized silver sponge with central platinum wire; B = clear lucite outer casing; C = adhesive cement sealing core from terminal attachment above it; D = terminal stud attachment.

coating the platinum wire with silver has an advantage over coating it by electrodeposition from a potassium silver cyanide solution in that contamination by cyanide ion, requiring long washing, is avoided. The loop at the end of the wire is then dipped in the silver oxide paste and reduced as before. This step may be repeated until a silver sponge is built up of the desired size, about 5 mm. in diameter. The electrodes are then chloridized in a 0.75 *M* solution of hydrochloric acid for four hours at a current of 4 m.a. per electrode, using a platinum wire as cathode. They

[2] G. J. Janz, and Harry Tanaguchi. The silver-silver halide electrodes: preparation, stability, and standard potentials in aqueous and non-aqueous media, *Chem. Rev.*, 53, 1953, 397-437.

are then washed with distilled water and dried. The glass tubing is then carefully broken away from the platinum wire, after which they are ready to be sealed into the electrode casings.

(3) Terminal attachment. The terminal attachment is made with a 7/16 in. Nu-Way Snap stud, which has been center-drilled with a No. 60 drill and cut down in length to about 3 mm. The platinum wire of the silver-silver chloride core is threaded up through the center hole in the casing. Before screwing on the terminal stud, the center hole is sealed with a drop of Sauereisen Insa-Lute adhesive cement, which is allowed to harden for 24 hrs. The terminal stud is then screwed tightly into the center column, taking care to thread the platinum wire of the core through the hole previously drilled in the stud. A small amount of adhesive cement placed on the under side of the top of the terminal stud before it is screwed down effects a permanent seal and strengthens the terminal assembly. The platinum wire, which extends somewhat above the terminal stud is trimmed down and soldered. The central chamber of the casing is now filled with electrode paste, or whatever contact medium is being used and stored in a small plastic box, which has been provided with holes fitted with $\frac{3}{8}$-in. outside-diameter grommets through which the center column of the electrode fits snugly. This method of storage prevents the electrode paste from drying out and facilitates handling of the electrodes. Attachment of recording leads to the studs may be made by using Nu-Way Snap Terminals. Electrode pairs must always be stored shunted. We find that they come into equilibrium in a day or two and may then be paired off.

Twenty-four electrodes were prepared for testing. Tests were made in saline electrode paste and recorded on an Offner Type R Dynagraph, at an amplification of 0.5 mv./cm. The electrodes were randomly divided into 12 pairs. In all cases, no drift was apparent over a 1-hr. recording period, which would indicate any drift present to be below ± 0.01 mv./hr.

Electrode bias was determined for all possible combinations of pairs ($N = 276$). The range of these measures, disregarding sign, was from 0.00 to 0.73 mv. The mean bias, again disregarding sign, was 0.17 mv. These bias potentials would be generally considered negligible at the levels of amplification used in skin-potential recording. We have found the electrodes to be stable within this range for periods of a year or more if properly stored.

It is thus apparent that this type of electrode has the characteristics desired for accurate recording of skin potentials: low bias potential, freedom from drift, and long-term stability.